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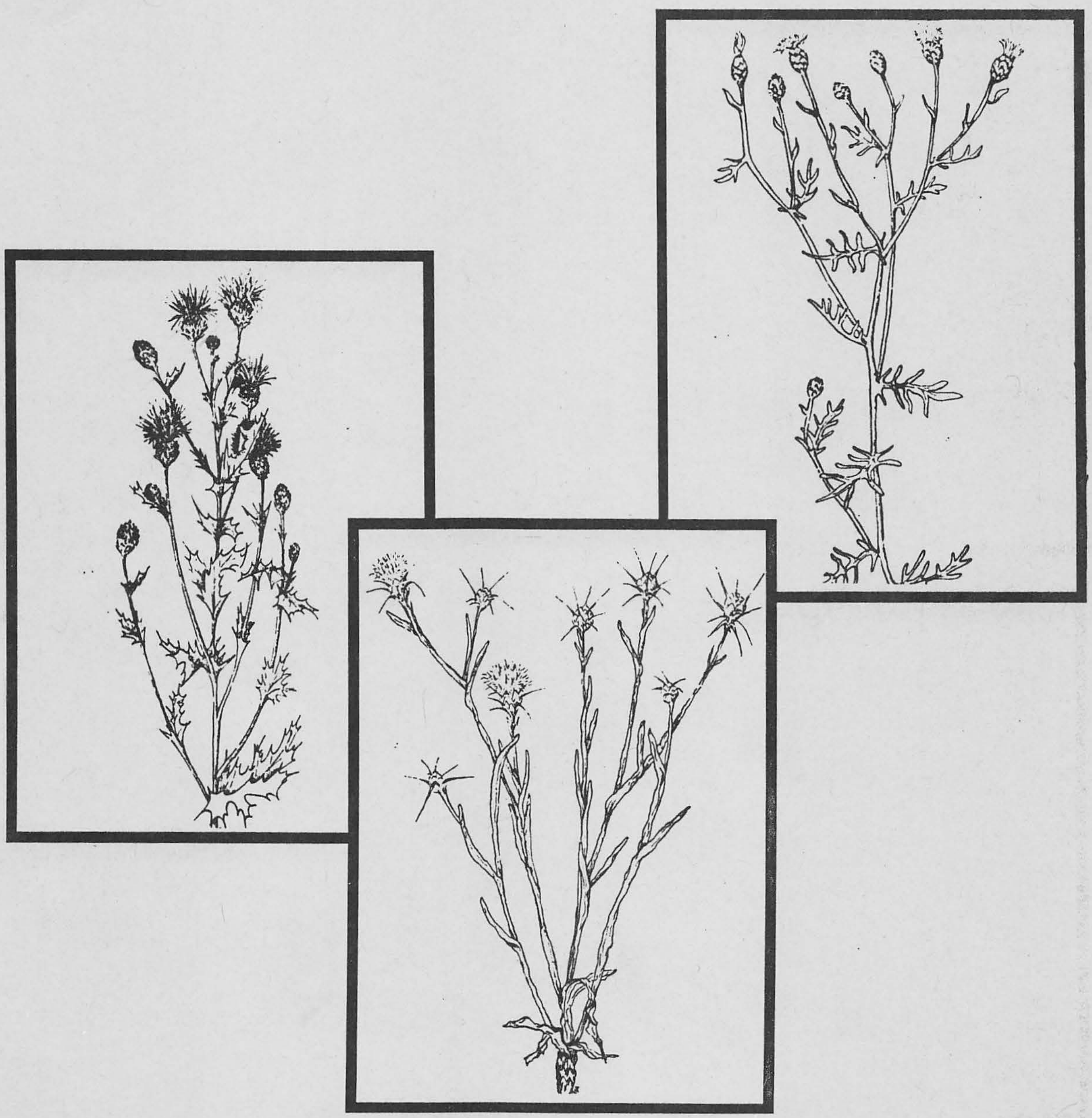
A Summary of the Status of Biological Control of Major Noxious Weed Species in Idaho, Montana, and North Dakota



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A SUMMARY OF THE STATUS OF BIOLOGICAL CONTROL OF MAJOR NOXIOUS WEED SPECIES IN IDAHO, MONTANA, AND NORTH DAKOTA

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INTRODUCTION

This paper summarizes the status of biocontrol efforts for noxious weeds in Idaho, Montana, and North Dakota. This summary is divided into three sections. The first section discusses the status of biocontrol agents for eight noxious weeds: spotted knapweed, diffuse knapweed, leafy spurge, musk thistle, Canada thistle, rush skeletonweed, yellow starthistle, and St. Johnswort (goat weed). The second section provides information on the state, federal, and university personnel involved in biocontrol efforts. The third section suggests ways in which land managers involved in noxious weed control can integrate biological control into a program of noxious weed control.

SECTION 1. BIOCONTROL AGENTS SPECIFIC TO NOXIOUS WEED SPECIES

1.1 SPOTTED KNAPWEED (*Centaurea maculosa*)

1.1.1 Seed Head Flies (*Urophora affinis* and *U. quadrifasciata*)

Adult flies lay one or more eggs in the knapweed flower bud. Galls induced by larvae in the seed head reduce seed production both in the infested seed head and in seed heads of the same plant that have not been directly attacked. *U. quadrifasciata* produces two generations per year. This species spread from a Canadian introduction and has dispersed rapidly through western Montana. In many cases it has dispersed prior to significant populations buildup on a site. Initial monitoring indicates that higher populations of *U. affinis* are found on many sites.

Both species are well-established in Montana and Idaho. Monitoring in western Montana indicates that some localized sites contain an average of four or more galls per seed head with single seed heads containing as many as 24 galls (Story and Nowierski 1984 and Story et al. in press). Other knapweed populations have not been infested, indicating opportunity for additional distribution efforts.

Seed head flies can reduce seed production by as much as 90 to 95 percent (Harris 1980a and 1980b as cited in Story and Nowierski 1984). This reduction may help slow the spread of knapweed, although in areas of high fly populations the seed production is still sufficient to maintain knapweed density. Therefore, reductions in knapweed populations are not expected from the activities of these fly species alone.

1.1.2 Root Boring Moths (*Pelochrista medullana* and *Agapeta zoegana*)

Root boring moths lay eggs on the knapweed rosettes. Larvae burrow into the root severely injuring or killing the plant. Preliminary evidence indicates that larvae of *A. zoegana* can migrate through the soil to infest additional plants.

Agapeta zoegana was introduced near Corvallis, Montana in 1984, 1985, and 1986. A small percentage of the population introduced in 1985 successfully overwintered. On-going experiments with this moth will determine whether the species is best introduced as adults or as eggs and which site types are most suitable for introduction.

Agapeta zoegana has good potential to be an effective component of a biological control program for spotted knapweed. However, the species does not attack diffuse knapweed. Additional sites in western Montana will be selected for introduction of this moth in 1987.

The introduction of P. medullana has been hampered by the small numbers of larvae available for introduction. Funding levels have limited collection efforts in Europe.

1.1.3 Seed Head Moth (Metzneria paucipunctella)

The seed head moth specifically attacks spotted knapweed. The larvae consume seed directly, in contrast to the galls induced by Urophora sp. (seed head flies) which reduce seed development.

This moth is well established on several sites in Idaho, Oregon, and Washington and on at least one site in western Montana. The spread of the moth has been hampered somewhat by the severe climate of Montana; however, the prognosis is still favorable based on successful introductions in British Columbia. Additional introductions are planned for western Montana.

1.1.4 Sclerotinia

This fungus occurs naturally in Idaho, Montana, and North Dakota as well as other states where it attacks a variety of plant species including commercially significant species such as sunflower, safflower, legumes, and lettuce. Instances of lethal attack on knapweed by native Sclerotinia have also been noted.

Researchers at Montana State University are developing variants with increased host specificity for noxious weeds, specifically knapweed (all species), Canada thistle, and yellow starthistle. In 1986, a major milestone was noted in this project. The U.S. EPA approved the experimental release of a first cycle mutational variant of Sclerotinia to the environment. This is the first time U.S. EPA has approved release of a genetically altered fungus. The host specificity of this variant has been narrowed such that it no longer attacks sunflower, safflower, and legumes.

Environmental introductions of this variant made in October 1986 will test the ability of this variant to overwinter. In addition researchers at Montana State University will continue development of a second cycle mutational variant of Sclerotinia with further narrowed host specificity.

1.2 DIFFUSE KNAPWEED (*Centaurea diffusa*)

1.2.1 Seed Head Flies (*Urophora affinis* and *U quadrifasciata*)

These flies attack both diffuse and spotted knapweed. See discussion under Section 1.1.1.

1.2.2 Root Boring Beetle (*Sphenoptera jugoslavica*)

Larvae of this beetle bore into roots destroying established plants. This beetle, which is specific to diffuse knapweed, is well established in Oregon and Washington. The beetle was released in large numbers in Montana in 1986 and populations will be monitored in 1987 to determine the ability of this species to overwinter and sustain itself over time.

1.2.3 *Sclerotinia*

See discussion under spotted knapweed.

1.3 LEAFY SPURGE (*Euphorbia esula* complex)

1.3.1 Leafy Spurge Hawkmoth (*Hyles euphorbiae*)

Hawkmoth larvae defoliate the plant, thus reducing carbohydrate reserves. This moth was originally established in Montana at sites near Bozeman and Missoula in 1966. The moth has been redistributed to several other sites in Montana. Although each larvae can defoliate up to 35 or more plants in a lifetime, the impact thus far on plant densities, rate of spread, or seed production at infested sites has been minimal. Leafy spurge has a remarkable resilience in the face of defoliation, in part because of significant root reserves.

Researchers at the USDA Agriculture Research Service Lab in Bozeman are developing a method for mass rearing hawkmoth in the lab using an artificial feed media. This method may be available for operational implementation soon.

Redistribution efforts in 1986 were hampered by the appearance of a nuclear polyhedrosis virus in some populations of hawkmoth. This virus may be endemic in hawkmoth, expressing itself under high population conditions, or it could have been contracted from a closely related lepidopteran species. In either case, long-term effects on hawkmoth populations are not clear, although additional evidence will be available in 1987.

1.3.2 Stem and Root Boring Beetle (*Oberea erythrocephala*)

As reported in *Weed Science* (Rees et al. 1986), this beetle had been successfully established on at least two sites in Montana by 1985. In 1986, the beetle was confirmed at a third site in Montana and one site in North Dakota. Both the adults and larvae attack the host plant. Adults feed

externally on stems and leaves. Young larvae mine the pith of the stem causing the stem to wilt and dry, and the older larvae feed on the crown and the roots.

The spread of this beetle is limited somewhat because it produces only one generation per year and because funding levels have limited European collection efforts.

1.3.3 Flea Beetles (*Apthona flava* and *A. cyprusus*)

Adults of these species feed on the foliage of leafy spurge. Females burrow to hair roots and deposit eggs. The larvae then burrow though the roots severely disrupting root function.

Apthona flava was introduced to several sites in Montana and North Dakota in 1985 and 1986. Monitoring in 1987 will determine its ability to overwinter and sustain populations under prevailing environmental conditions. *Apthona cyprusus* has been released on one site in North Dakota.

1.3.4 Gall-Forming Midge (*Bayeria capitigenia*)

This delicate fly lays its eggs on the growing tip of the leafy spurge plant. The larvae cause the leaves of the growing tip to form a gall which does not allow the plant to flower, thus reducing seed production. This species was introduced for the first time in 1985 and 1986 at four sites in Montana and one site in North Dakota. If this fly succesfully overwinters, it could spread rapidly because it produces four or five generations per year.

1.3.5 Clear-Winged Moth (*Chamaesphecia tenthrediniformis*)

First introduction studies with this moth were failures in part because of the early lack of understanding of the number of varieties of leafy spurge present in this country and the host specificity of many insects. Current work with this species involves compatibility studies with several varieties of leafy spurge. This work is being conducted in European labs with spurge samples sent from the United States.

1.3.6 Leaf-Tying Moth (*Lobesia euphorbiana*)

The larvae of this moth tie the newly formed leaves together and feed internally, destroying the shoot and preventing seed production. Screening research is continuing. A release date for this moth has not been set.

1.4 MUSK THISTLE (*Carduus* sp.)

1.4.1 Seed Head Weevil (*Rhinocyllus conicus*)

Musk thistle reproduces by seed alone, and *R. conicus* larvae destroy the seed producing region of the flower head, dramatically reducing seed production.

The larvae destroy seed and induce a gall-like formation in the seed receptacle The gall acts as a metabolic sink. When more than nine larvae are present in the receptacle (more than 20 are possible), the viability of the remaining undamaged seeds is less than 2 percent. Larvae from eggs laid on the stem can also burrow into the stem.

This weevil is established throughout Montana, Idaho and North Dakota. The adults of this weevil are easily collected for redistribution to new infestations (see Section 3 of this review). After introduction significant reductions in thistle populations are eventually observed.

1.4.2 Crown Feeding Weevils (*Trichosirocalus horridus* and *Ceutorhynchus trimaculatus*)

Trichosirocalus horridus is well established in Virginia and in Canada. Releases in Montana have not been successful because of subsequent site disturbances and possible lack of winter hardiness of weevils from Virginia. Future site releases will involve weevils from Canada.

Ceutorhynchus trimaculatus is being screened for release.

Larvae of both weevils attack the terminal shoot of the plant and destroy the meristem. In response, the plant increases lateral shoot growth and produces more and smaller seed heads, a condition that is more favorable to attack by *R. conicus*.

1.4.3 Stem Gall Fly (*Chelossa grossa*)

The larvae of this fly bore into the stem of the thistle and induce a gall formation. Screening research on this fly continues.

1.5 CANADA THISTLE (*Cirsium arvense*)

1.5.1 Stem Boring Beetle (*Ceutorhynchus litura*)

The beetle lays its eggs on a newly emerged plant very early in the growth cycle (virtually as soon as the snow has melted in some areas of Montana). The larvae bore down the stem and into the root crown. The openings created by the larvae departing the root and stem apparently provide access for various insects and/or pathogens. Although newly attacked plants do not appear to be affected, recent monitoring indicates that 96 percent of attacked plants do not survive the winter, compared to 4 percent mortality in unattacked plants.

This beetle is established on several sites in Montana but has been slow to increase and spread on its own. The beetle can be collected for redistribution. Additional details on collection are provided in Section 3.

1.5.2 Gall Fly (*Urophora cardui*)

The larvae of this species invade the stem of the plant inducing gall formation. Both main and auxilliary stems are subject to attack. This fly is reported established on at least one site in Montana. Introduction efforts in Idaho and Montana have been hampered by the limited availability of insects and restrictive habitat requirements.

1.5.3 *Sclerotinia*

The successful attack of Canada thistle by an isolate of *Sclerotinia sclerotiorum* has been reported in the literature (Brosten and Sands, 1986). Field tests in Montana showed thistle shoot kill ranging from 20 to 80 percent and subsequent reduction in thistle density the following year. Generally *S. sclerotiorum* is not a vigorous competitor in the soil and carryover of fungus from year to year is low. Thus, retreatment would be necessary. As discussed in Section 1.1.4, research to develop new strains of *Sclerotinia* is continuing at Montana State University.

1.6 RUSH SKELETONWEED (*Chondrilla juncea*)

This weed is spreading rapidly in northern and southwestern Idaho and eastern Washington and Oregon. This species is reported to be present on over 3 million acres in Idaho (Lee 1986). In 1979 no rush skeletonweed was reported in Montana. By 1985 the weed was reported in seven counties, although a complete inventory is not available.

This weed spread with catastrophic effects over millions of acres in Australia earlier this century prior to initiation of a very successful biocontrol program. The article by Lee cited above contains a good review of the status of biological control efforts for rush skeletonweed. This article is the source of much of the information presented below.

1.6.1 Rust (*Puccinia chondrillina*)

The rust is credited with a primary role in successful biological control of rush skeletonweed in Australia. For example, in the shire of Canberra the average number of plants per square meter fell from 233 in 1971, to 2 in 1976 after introduction of this rust (University of Idaho, 1986).

Various strains of *P. chondrillina* have been established in the U.S. and the rust can be distributed by a variety of methods including aerial application. Although this rust has been very successful in controlling rush skeletonweed in several areas of this country, control efforts have been hampered by the appearence of several biotypes of skeletonweed with varying suceptibilities to different strains of this rust. A proposal for additional research and inventory work has been submitted to USDA-APHIS by the State of Idaho and the University of Idaho. As proposed, this project would determine the number of biotypes present, their location and extent, and their susceptibility to various strains of rust.

1.6.2 Gall-Forming Midge (*Cystiphora schmidti*)

Females of this species lay eggs under the epidermis of leaves and stem of the plant. Distinct reddish-purple round or elongated galls form within 10 days and larvae feed on leaf mesophyll or stem cortex. Over 4,000 galls entirely covering the leaves and stems of an individual plant have been observed. Photosynthesis and reproductive capabilities of infected plants are severely reduced.

This midge has been well established in southwestern Idaho, with additional colonies in Oregon, Washington, and California. This midge does not distinguish among the rush skeletonweed biotypes. This midge can multiply rapidly since it produces four or five generations per year.

Extensive predation of galls by grasshoppers, primarily *Melanoplus sanguinipes*, and predation of larvae and pupal stages by a ptermalid wasp have been observed to reduce midge population by up to 70 percent. However, the midge has a good reproductive capacity and high populations can continue to flourish.

1.6.3 Gall-Forming Mite (*Aceria chondrillae*)

Adult mites overwinter in rosettes of young plants and then move to the stems as the plants bolt in the spring. Gall formation is induced by mite feeding on the flower buds or stems. Seed production can be eliminated and plant vigor greatly reduced by high population of mites.

This mite will infest all biotypes of rush skeletonweed. The mite is easily spread by wind and can also be distributed by transporting galled plants containing mites from one location to another. Mite populations can also be maintained in greenhouses and released when the plant begins to flower.

1.7 YELLOW STARTHISTLE (*Centaurea solstitialis*)

1.7.1 Seed Head Weevil (*Bangasternus orientalis*)

The larvae of this species destroy the seeds of this thistle. Data are not yet available on the extent of seed reduction.

This weevil was introduced in Idaho in 1985 and has successfully overwintered. Several additional biological agents will also be necessary to control yellow starthistle effectively.

1.8 ST. JOHNSWORT or GOAT WEED (*Hypericum perforatum*)

1.8.1. Defoliating Beetle (*Chrysolina quadrigemina*)

It has been said that monuments could be raised to this Chrysolina beetle in California where the beetle reduced several million acres of weed infestation

to non-destructive levels. Indeed, the town of Eureka, California has on display a 6-foot bronze statue of this beetle.

This beetle has also successfully reduced weed infestations in Montana in several locations. In other locations the beetle has been less successful, possibly because the absence of fall rain delays beetle reproduction. Research will be conducted to determine the possible positive effects of weed irrigation.

1.8.2 Root-Boring Beetle (*Agrilus hyperici*)

The larvae of this species bore through roots of the weed and greatly reduce plant vigor. This species is well established in California and probably also in Oregon, Idaho, and Washington. Establishment in Montana has been more difficult in part because of the requirement for fall moisture and the unusual climatic conditions during the past several years in Montana. Introduction attempts will continue.

1.8.3 Defoliating Moth (*Anaitis plaigata*)

This defoliating moth is well established in Canada. Clearance is being sought for introduction into the U.S. This moth tolerates dry climates and should do well in Montana.

1.8.4 Gall-Forming Midge (*Zeuxidiplosis giardi*)

The larvae of this midge induce gall formation on the stems of the plant. These galls tie up newly formed leaves. Formation of 17 or more galls on a stem generally kills the stem. Release of this midge in Montana is anticipated in 1987.

SECTION 2. AGENCIES AND PERSONNEL INVOLVED IN THE INTRODUCTION, ESTABLISHMENT, AND MONITORING OF BIOLOGICAL CONTROL AGENTS FOR NOXIOUS WEEDS

The successful introduction of biocontrol agents requires a long term commitment and coordinated activity among personnel involved in the identification, collection, screening, quarantine, introduction, establishment, and evaluation of biocontrol agents.

After a biocontrol agent has undergone initial screening in Europe for host specificity, collections are screened further at the USDA Agriculture Research Service's Biological Control of Weeds Laboratory (Albany, California). This quarantine lab also insures the health and viability of the population and removes ancillary parasites and diseases.

A new quarantine laboratory is currently being constructed at Montana State University in Bozeman. Funding for the building was provided by the state of Montana. Funding for the laboratory equipment is being provided primarily by USDA ARS. Additional funding for a required quarantine officer has not been

secured at the present time. If necessary funding can be secured, this new laboratory could relieve some of the pressure on the Albany laboratory which is responsible for introduction efforts for the entire country.

After the biocontrol agent has been approved for release, the quarantine laboratory then distributes populations of the agent to local Agriculture Research Service stations, state research, or extension agencies. Local personnel are responsible for the release and monitoring of the agent. Careful monitoring of the agent is required to determine the optimum conditions for release; to assess causes of introduction failures, if necessary; and to aid in redistribution efforts.

The following is a list of persons who are involved in biological control efforts for noxious weeds in the States of Idaho, Montana, and North Dakota:

IDAHO

Name	Affiliation	Focus
Robert Callihan	Dept. of Plant, Soil, and Entomological Sciences University of Idaho Moscow, Idaho 83843 (208) 885-6617	Yellow starthistle Rush skeletonweed Knapweed Leafy spurge
James Johnson	Dept. of Plant, Soil, and Entomological Sciences University of Idaho Moscow, Idaho 83843 (208) 885-6617	Yellow starthistle Knapweed
Gary Lee	Idaho Agric. Exp. Stn. University of Idaho Moscow, Idaho 83843 (208) 885-7173	Rush skeletonweed Yellow starthistle Knapweed
Joseph McCaffrey	Dept. of Plant, Soil, and Entomological Sciences University of Idaho Moscow, Idaho 83843 (208) 885-7548	Rush skeletonweed Yellow starthistle Knapweed Leafy spurge

MONTANA

Name	Affiliation	Focus
Robert Nowierski	Dept. of Entomology Montana State University Bozeman, MT 59717 (406) 994-5080	Leafy Spurge Knapweed
Norman Rees	Rangeland Insect Lab. USDA ARS c/o Montana State University Bozeman, MT 59717 (406) 994-3344	Leafy Spurge Musk Thistle Canada Thistle St. Johnswort

Name	Affiliation	Focus
Robert Richard	APHIS Forestry Sciences Lab. Montana State University Bozeman, MT. 59717 (406) 994-4852	Knapweed Leafy Spurge Rush Skeletonweed
David Sands	Dept. of Plant Pathology Montana State University Bozeman, MT 59717 (406) 994-5151	Development of Sclerotinia to control knapweed, Canada thistle, etc
Jim Story	Western Montana Agric. Research Station 531 NE Quast Lane Corvallis, MT 59828 (406) 961-3025	Knapweed (all species) Leafy Spurge Dalmation Toadflax

NORTH DAKOTA

Robert Carlson	Entomology Department North Dakota State University Fargo, ND 58105 (701) 237-7906	Leafy Spurge
Robert Hosford	Department of Plant Pathology North Dakota State University Fargo, ND 58105 (701) 237-7079	Leafy Spurge

SECTION 3. SUMMARY OF BIOLOGICAL CONTROL OPTIONS AVAILABLE TO THE LAND MANAGER

3.1 MUSK THISTLE (*Carduus sp.*)

Rhinocylus conicus has proved an effective control of musk thistle. A pamphlet entitled "Collecting, Handling, and Releasing *Rhinocyllus conicus*, a Biological Control Agent of Musk Thistle" (USDA Agriculture Handbook 579) as well as a list of collectors of this weevil are available from Norm Rees (address above).

3.2 CANADA THISTLE (*Cirsium arvense*)

Collections of *Ceutorhynchus litura* are possible but require some persistence because of the size of the beetle and seasonal constraints. Norm Rees is an appropriate contact for collection information.

Operational releases of *Sclerotinia* to control Canada thistle on Army Corps of Engineers land have been made under contract to David Sands, Montana State University. Further releases are possible on a contractual basis.

3.3 KNAPWEED (*Centaurea* sp.)

As noted in Section 1.1.1, monitoring by Jim Story and others indicates that the seed head flies (*Urophora* sp.) are well established in Montana and Idaho. Opportunities for redistributing these flies exist particularly since *U. affinis* has been slower to spread. Jim Story has written a pamphlet titled "Collection and Redistribution af *Urophora affinis* and *U. quadrifasciata* for Biological Control of Spotted Knapweed" (Circular 308) which is available from the Cooperative Extension Service of Montana State University, Bozeman. The USDA Animal and Plant Health Inspection Service (APHIS) is funding a project to facilitate the spread of biocontrol agents on knapweed. Bob Richard is continuing the site surveys for the presence of *Urophora* seed head flies. He will also be coordinating redistribution efforts of these biocontrol insects and other agents as they become available. In addition, several counties in Montana will be continuing local redistribution efforts.

Initial introduction and redistribution efforts with the root boring moths (*Agapeta zoegana*) are being conducted by Jim Story. Assuming continued adequate funding for establishment efforts, root boring moths could be available for wider redistribution efforts in 2 or 3 years.

3.4 LEAFY SPURGE (*Euphorbia esula*)

Information on the redistribution of hawkmoth can be obtained from Bob Nowierski. Other biocontrol agents for leafy spurge will require several more years of work on introduction.

3.5 RUSH SKELETONWEED (*Chrondrilla juncea*)

As discussed in Section 1, a complement of three biological control agents can be used to control rush skeletonweed. A proposal has been submitted to APHIS for funding a 4-year effort to coordinate the biological control action for this weed in Idaho, Oregon, and Washington. Land managers with current large or growing infestations of this weed (including areas in Montana) should contact Joe McCaffrey, Gary Lee, or Bob Richard for further information on this coordinated effort.

Joe McCaffrey is currently drafting a handbook on the operational aspects of biological control of rush skeletonweed.

3.6 ST. JOHNSWORT or GOAT WEED (*Hypericum perforatum*)

Biological control of this weed has proved very successful in areas with milder climates. The chrysolina beetle has also successfully reduced several infestations in Montana, although results have been more variable. Norm Rees can advise land managers further on the biological control options available for this weed.

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